

Comparing the Variability in Simulated Hyperspectral Solar Radiance with Observations

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SDT Tasks

1. Trend Detection in SCIAMACHY Spectral Radiances

Task Summary

Objective: Extract trends in TOA outgoing shortwave spectral radiance.

Method: PCA, examining PC score time series, and SSA/MSSA for trend extraction.

Data: SCIAMACHY shortwave spectral radiance; radiative transfer simulations of TOA outgoing spectral radiance.

Models: PCA implemented through IDL/ENVI; SSA from published algorithms; MODTRAN.

Expected outcomes: Validation of trend detection methods using measured shortwave radiances and tested with modeled simulations with known forcings; improved quantification and refinement of CLARREO requirements.

SDT Tasks

2. Intersection of Spectrally Decomposed Subspaces

Task Summary

Objective: Find intersection of eigenvector subspaces in measured and modeled radiance data sets. Use to separate the underlying physical variables that explain the variance in the measurements.

Method: Numerical methods of determining the angles between the complementary linear subspaces. Look-up tables to match model input to variance as depicted by measurement eigenvectors.

Data: SCIAMACHY shortwave spectral radiance; radiative transfer simulations of TOA outgoing spectral radiance from Langley and UC Berkeley groups.

Models: PCA implemented through IDL/ENVI; MODTRAN; numerical model to derive angles between principle axes.

Expected outcome: Improved attribution techniques through identification of physical variables responsible for spectral variability; improved quantification and refinement of CLARREO requirements.

Recent Papers

Roberts, Y. L., P. Pilewskie, and B. C. Kindel, Evaluating the Observed Variability in Hyperspectral Earth-reflected Solar Radiance, *J. Geophys. Res.*, accepted (2011).

Coddington, O., P. Pilewskie, and T. Vukicevic, The Information Content of Hyperspectral Shortwave Cloud Albedo: Quantification and Practical Applications, *J. Geophys. Res.*, accepted (2011).

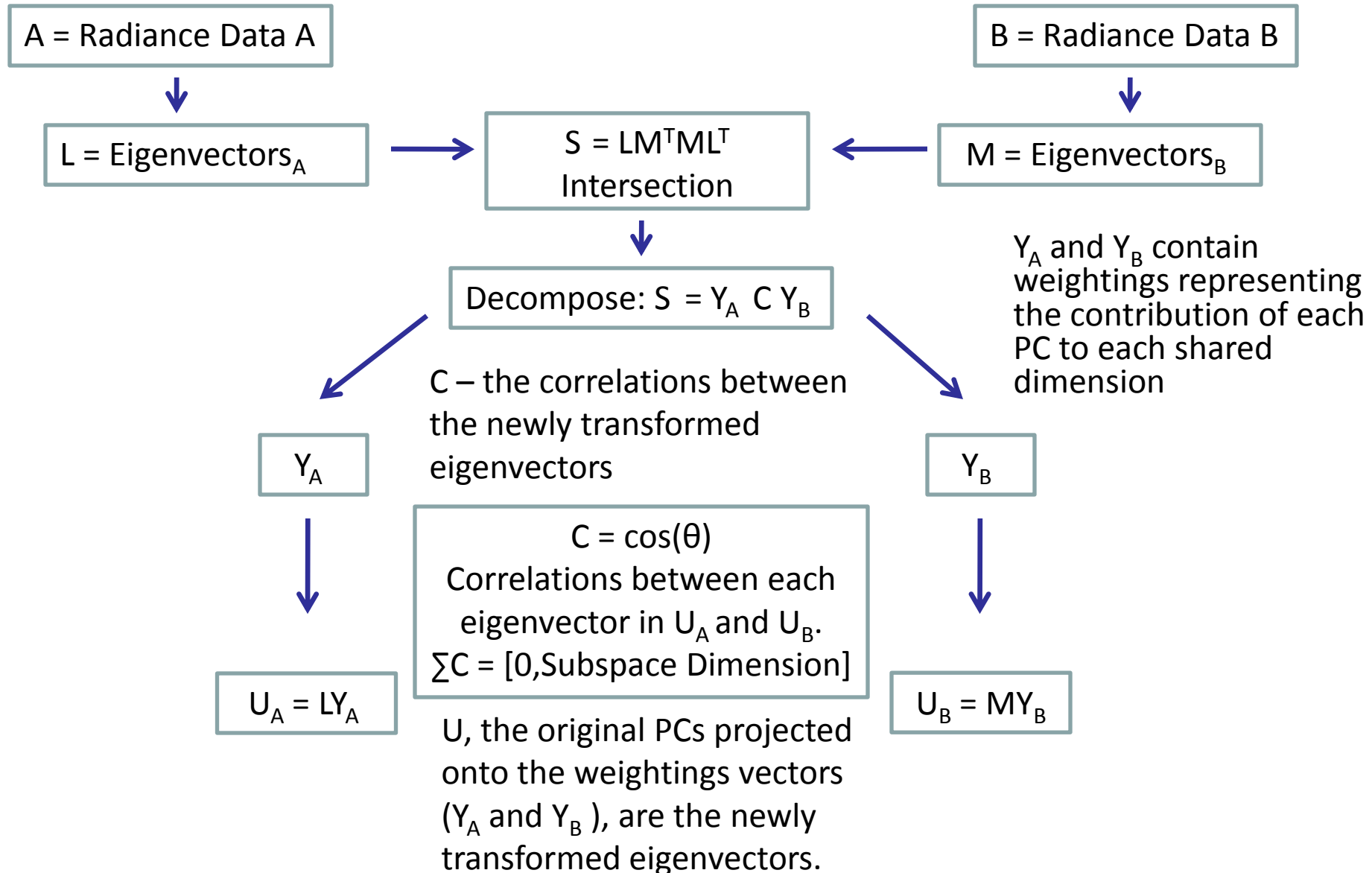
Outline

- Description of quantitative comparison methods of principal components
 - Test for significance: Are the subspaces the same?
- Unstandardized PCA results
- Transformation of some subset of dominant PCs and measures of their similarity
- Case Studies - OSSEs and SCIAMACHY data:
 - **October 2004**
 - **April 2004**
 - January 2004
 - July 2004

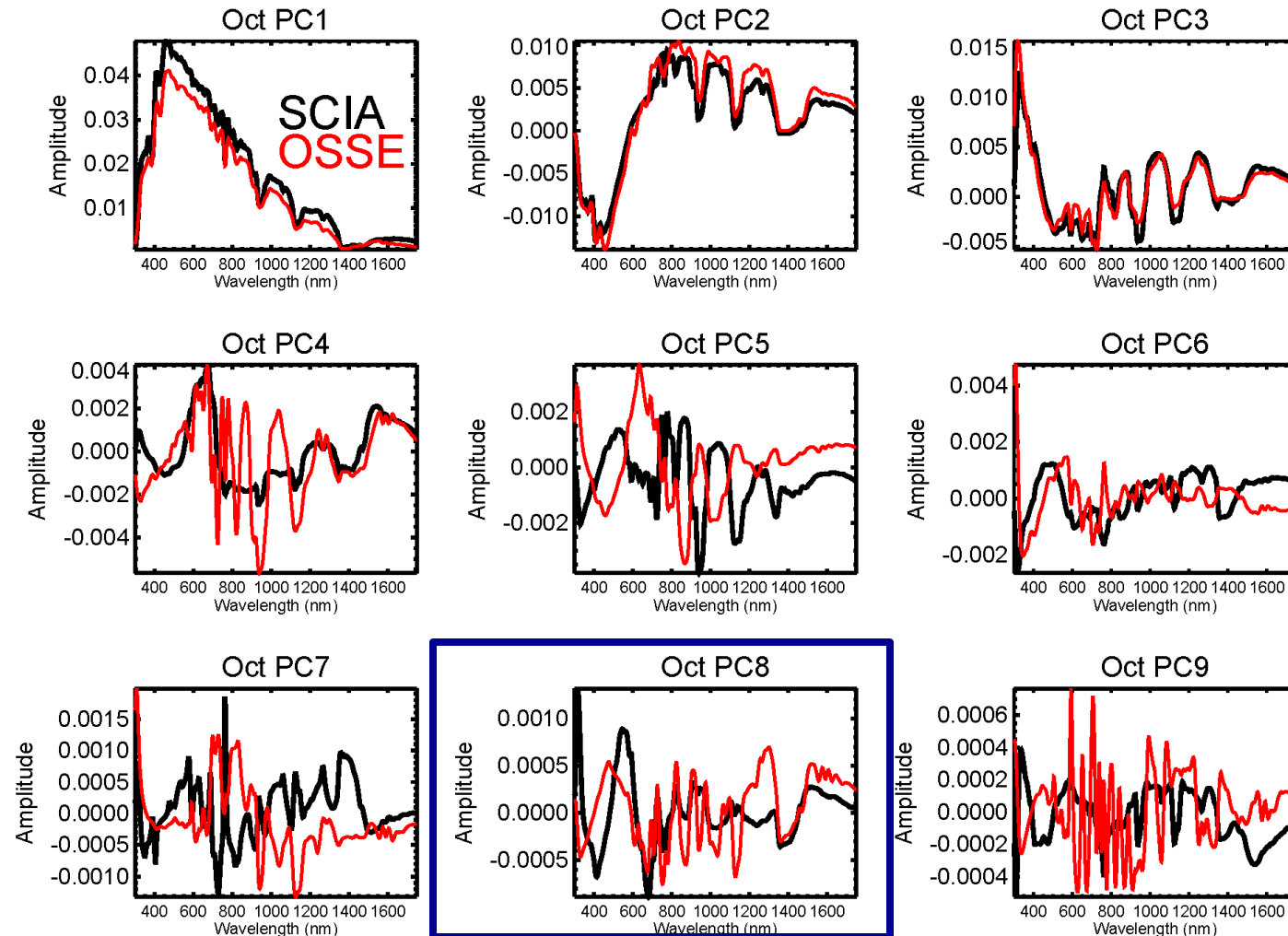
Comparing SCIAMACHY and OSSE Radiances

- SCIAMACHY nadir radiances
 - Spatial grid: 5.625° (4x the original OSSE output)
 - Resulting in monthly averaged, spatially gridded, 10 nm FWHM spectra
- Also spatially averaged and spectrally resampled OSSEs all-sky radiances over the same spatial grid and spectral resolution
 - Only used locations present in SCIAMACHY data

Quantitative Comparison of Subspaces

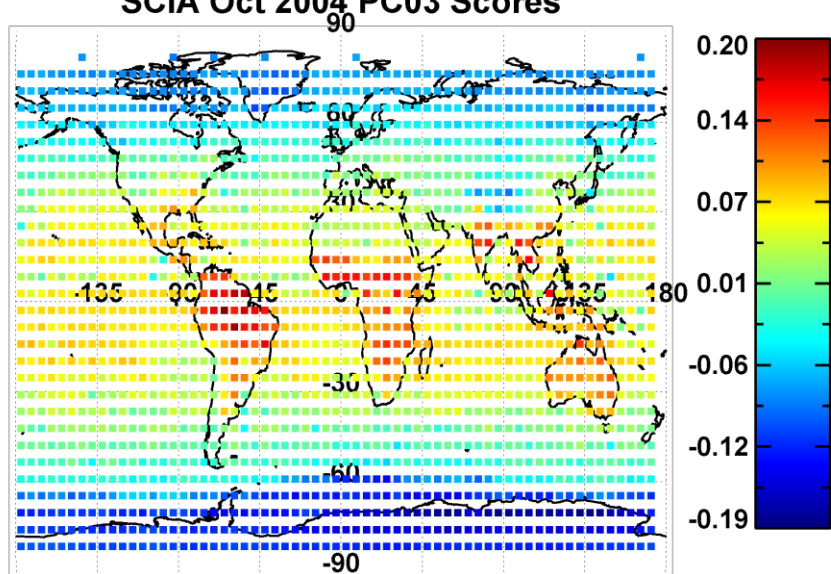


October 2004 Unstandardized PCs

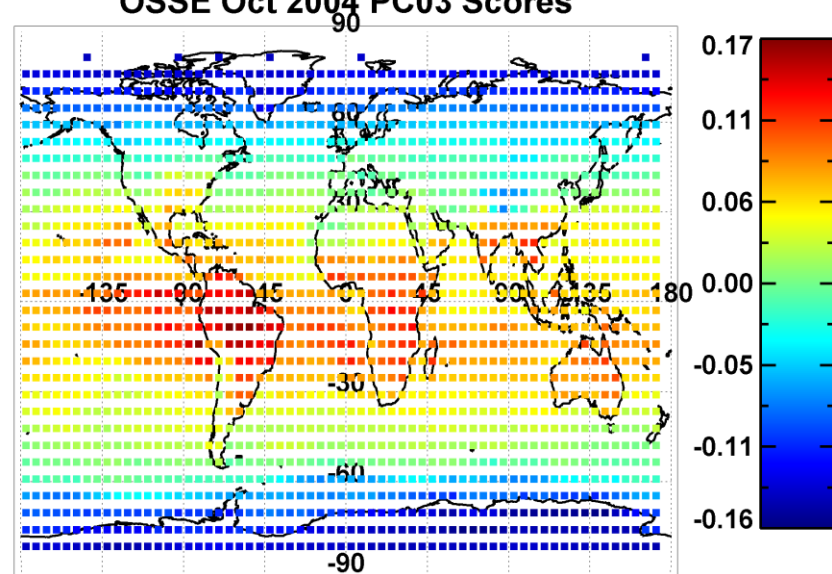


Nine eigenvectors from the principal component transformation of the measured SCIA radiance spectra (black) and OSSE MODTRAN spectra (red).

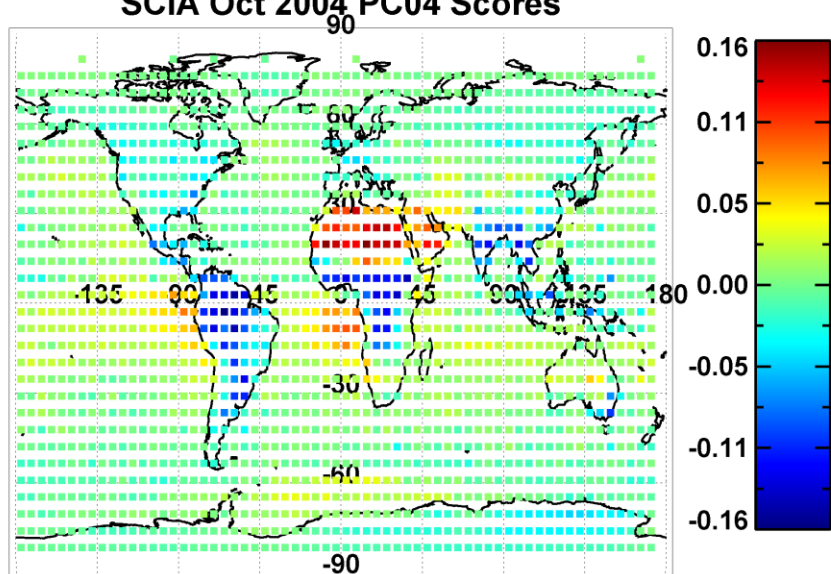
SCIA Oct 2004 PC03 Scores



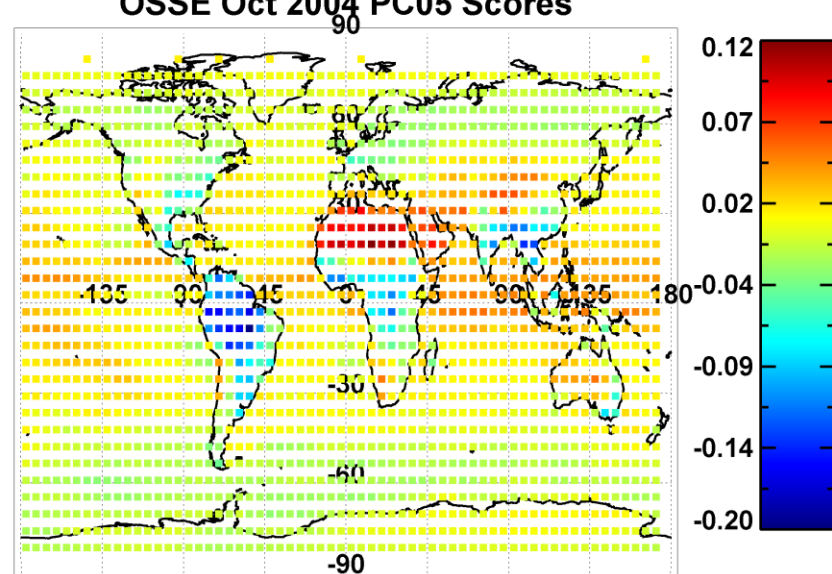
OSSE Oct 2004 PC03 Scores



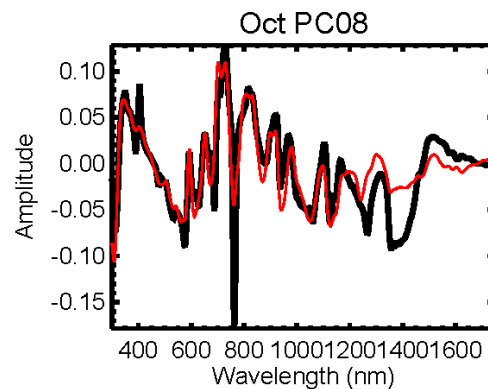
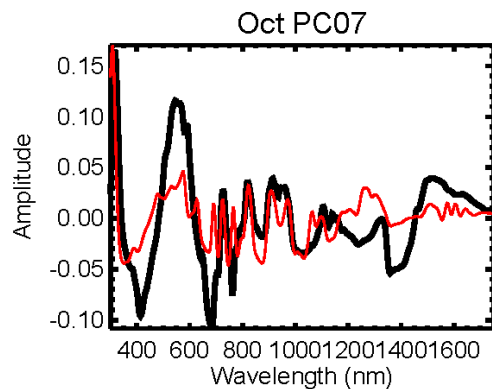
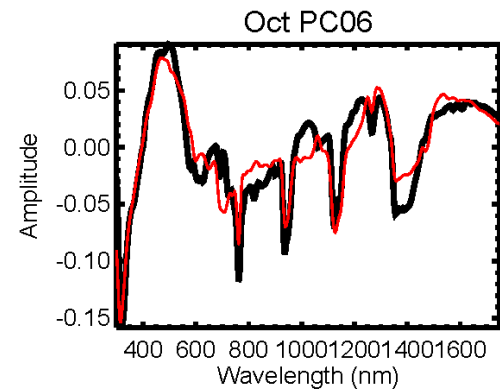
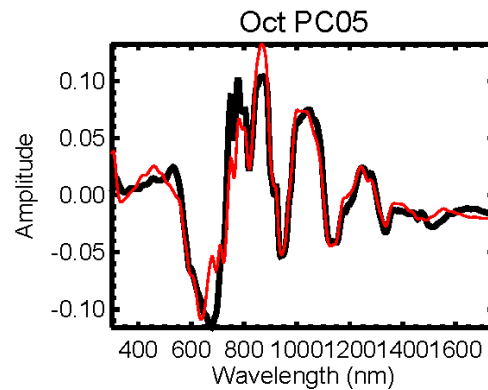
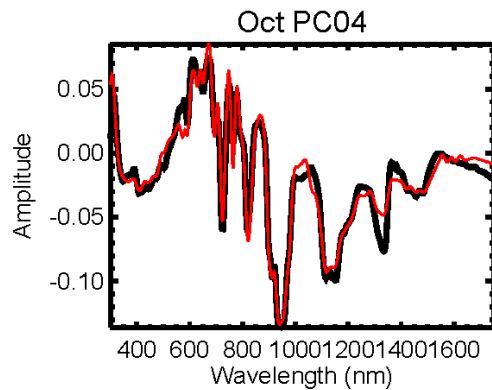
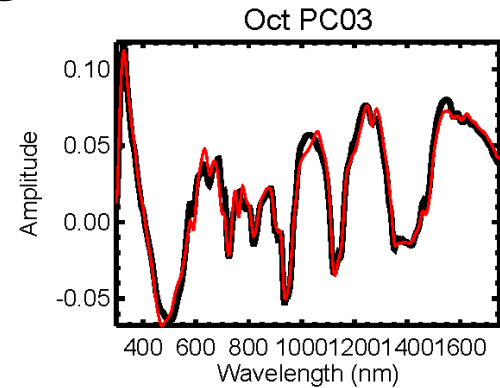
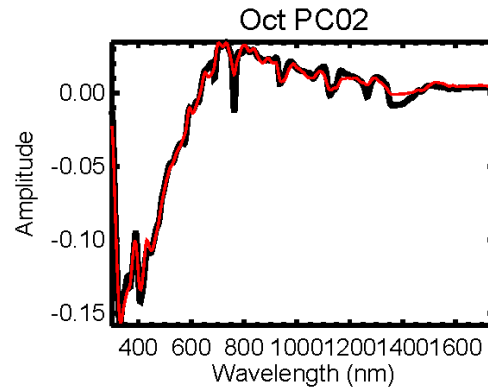
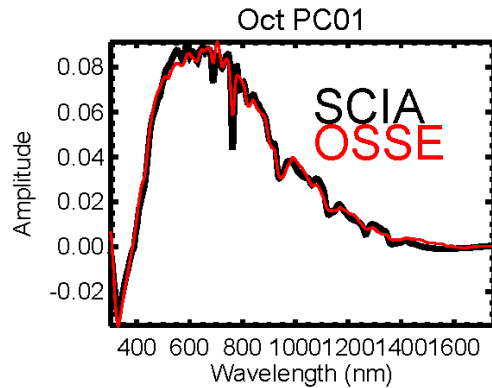
SCIA Oct 2004 PC04 Scores



OSSE Oct 2004 PC05 Scores



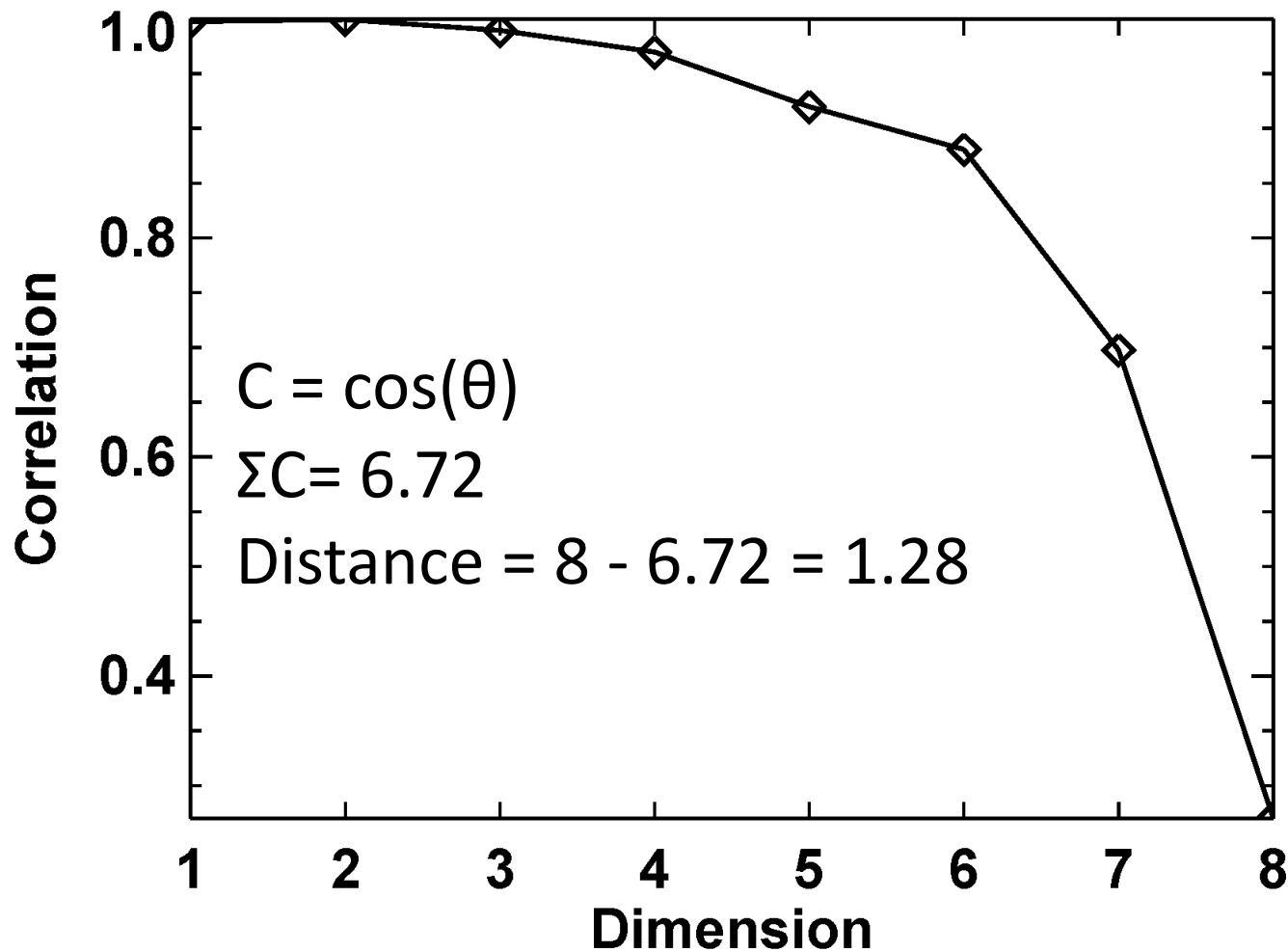
Transformations of the Intersecting Data - October



How can we *quantify* the similarity between these two data sets?

Eight eigenvectors of the transformed databases.

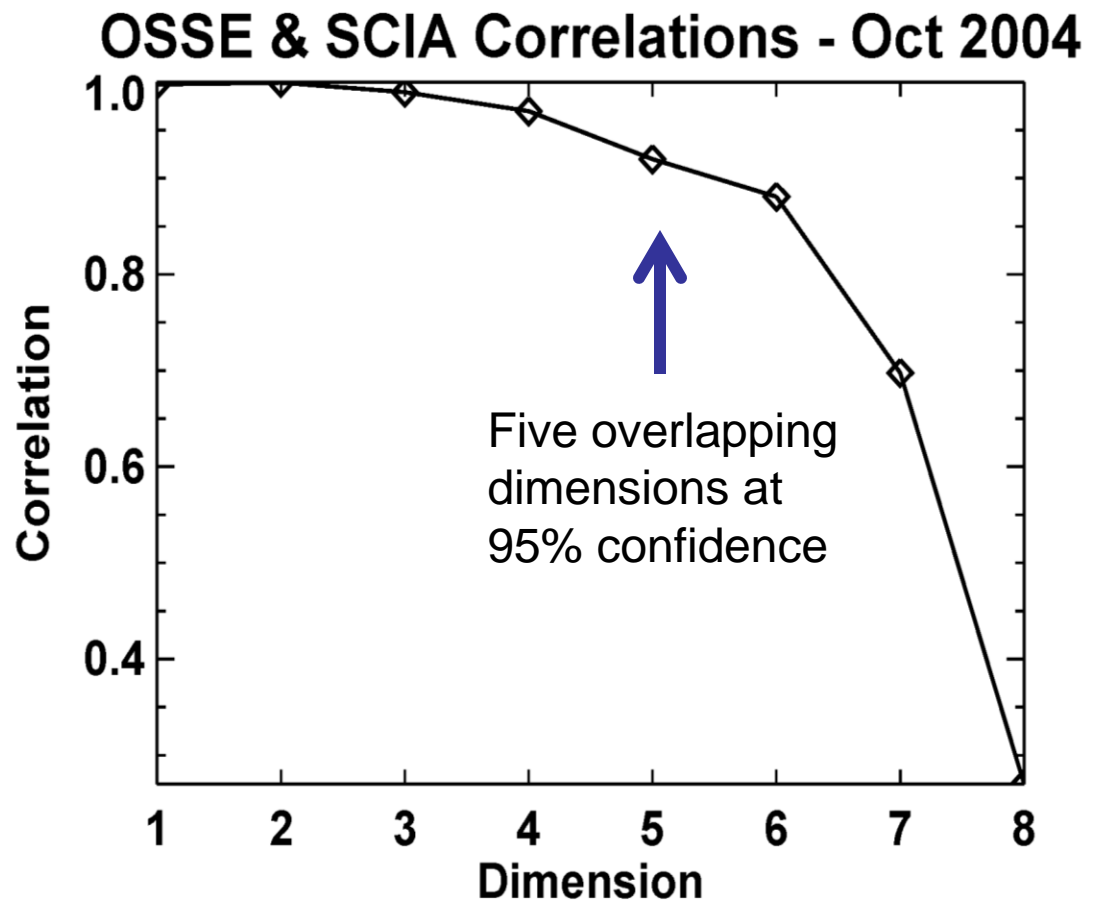
OSSE & SCIA Correlations - Oct 2004



Quality of overlap in SCIA and OSSE radiances measured by the angle between subspaces.

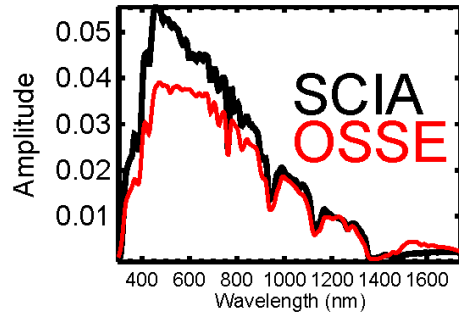
How can we *quantify* the similarity between these two data sets?

- Construct a 95% one-sided confidence interval by estimating the distribution of the distances between the subspaces
- The boundary of this confidence interval provides a lower bound of the distance
- If that boundary is greater than zero, we conclude that the distance is significantly greater than zero with 95% confidence.

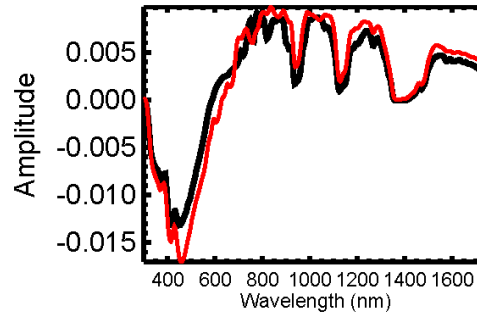


April 2004 Unstandardized PCs

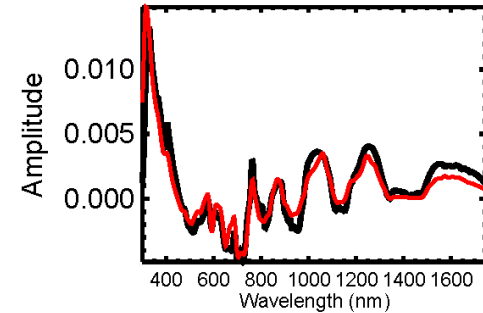
Apr PC1



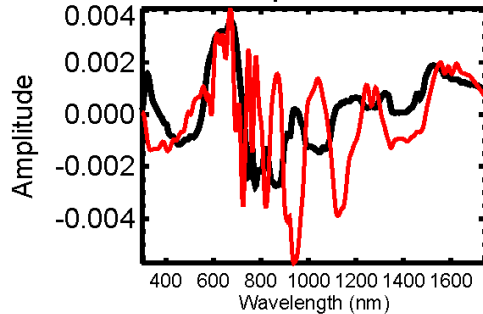
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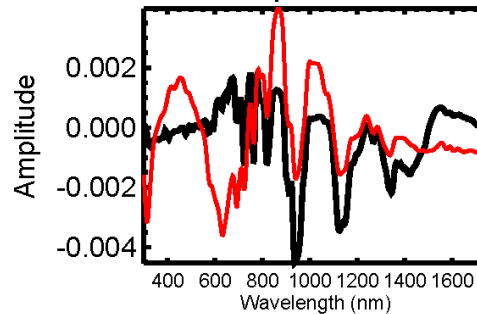
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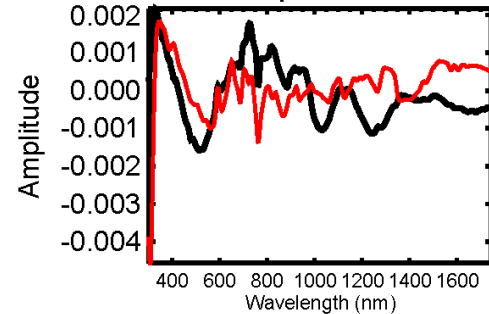
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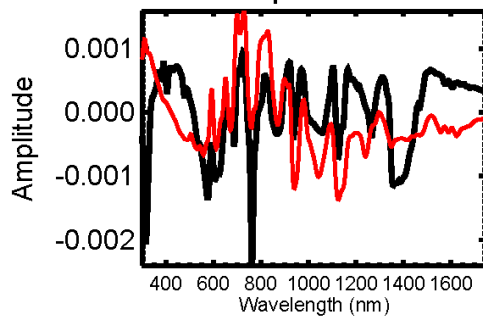
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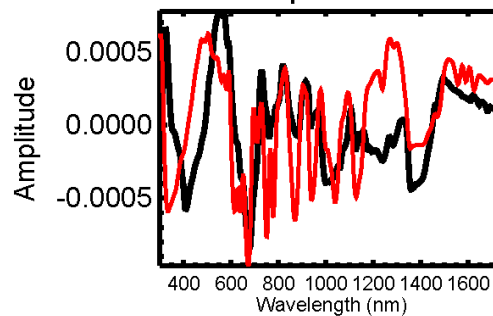
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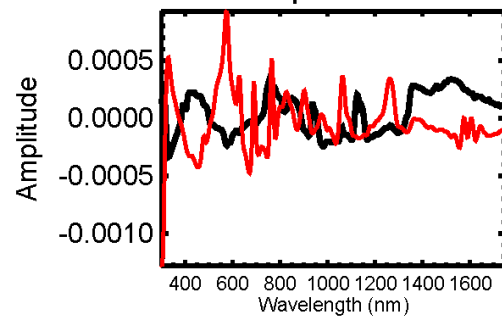
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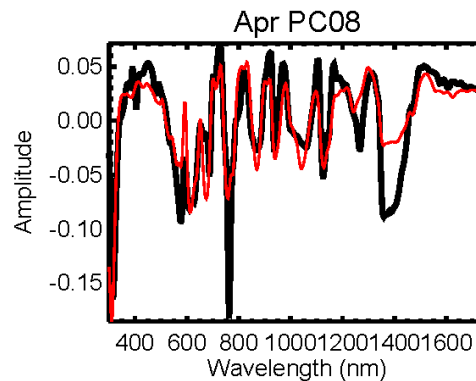
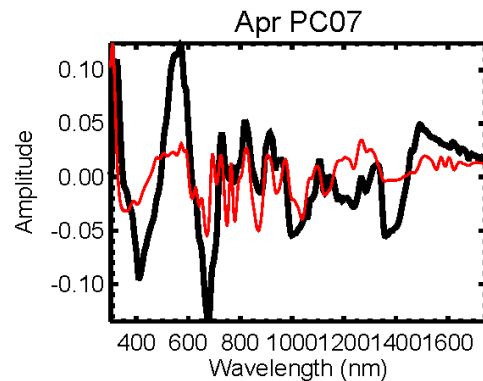
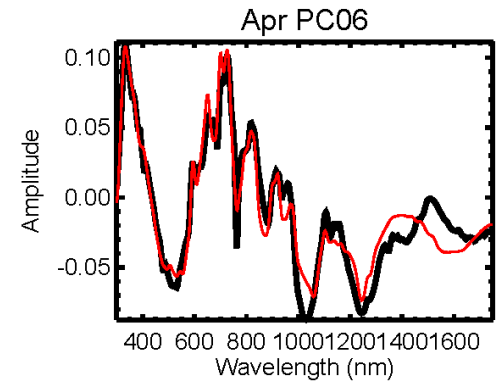
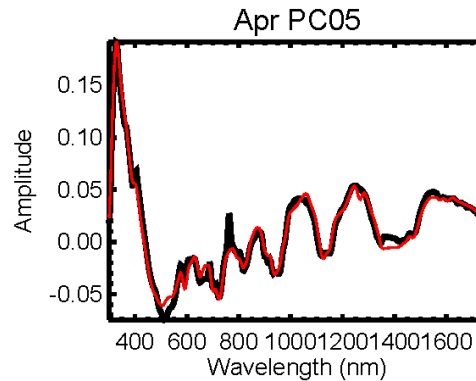
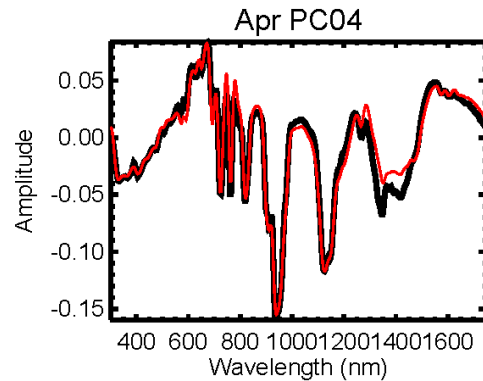
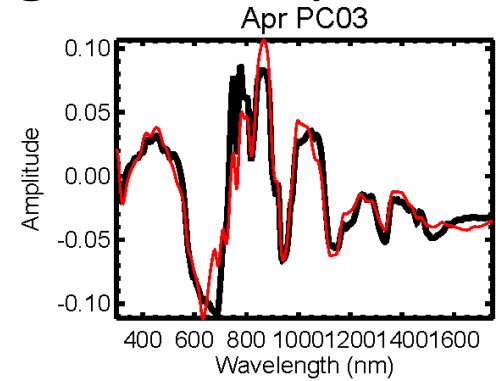
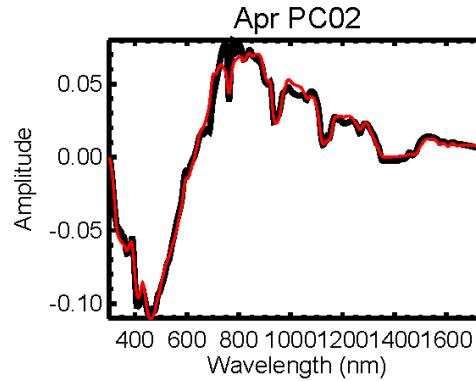
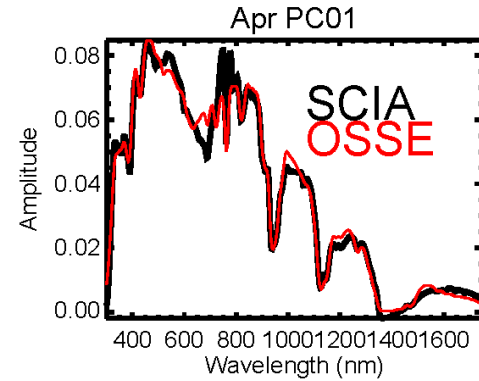
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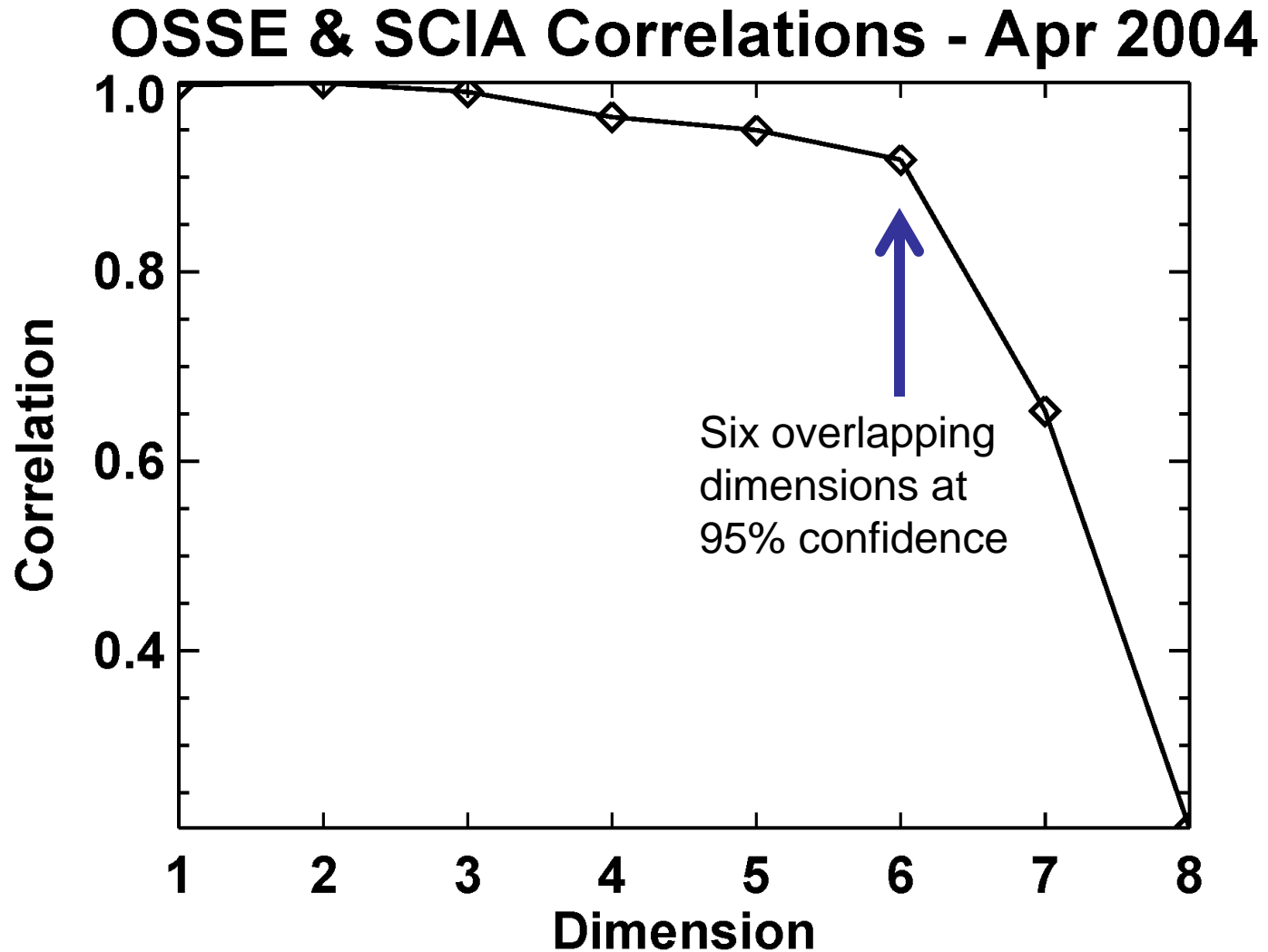


Apr PC9



Transformations of the Intersecting Data - April





Quality of overlap in SCIA and OSSE radiances measured by the angle between subspaces.

Summary

- Quantitative comparisons between multivariate data sets using principal component analysis
 - How similar are the modeled spectral radiances (OSSEs) to the measured spectral radiances (SCIAMACHY)?
- Statistical significance test of subspace similarity
 - Among the dominant modes of variability, how many transformed eigenvectors do the two subspaces have in common?

Ongoing and Future Work

- We have a good quantitative measure of similarities, but is there a way to identify/quantify the differences?
- **SCIAMACHY swath-to-grid algorithm**
 - Will be helpful with increased data availability
- Comparisons over longer periods of time
 - Observations – NASA database of SCIAMACHY radiances
 - Model Output – OSSE output over the course of the century with different emission scenarios
- **How does the OSSE variability change over the century?**
 - Our progressive distance technique has found significant distances between spectral solar radiances from constant and A2 emissions cases